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VELA NETWORK EVALUATION AND AUTOMATIC PROCESSING RESEARCH

QUARTERLY REPORT NO. 5

10 JULY 1976 TO 10 OCTOBER 1976

TEXAS INSTRUMENTS INCORPORATED
Equipment Group
Post Office Box 6015
Dallas, Texas 75222

Contract No. F08606-76-C-0011
Amount of Contract: $440,000
Beginning 15 July 1976
Ending 30 September 1976

Prepared for

AIR FORCE TECHNICAL APPLICATIONS CENTER
Alexandria, Virginia 22314

Sponsored by

ADVANCED RESEARCH PROJECTS AGENCY
Nuclear Monitoring Research Office
ARPA Program Code No. 6F10
ARPA Order No. 2551

10 October 1976

Acknowledgment: This research was supported by the Advanced Research Projects Agency, Nuclear Monitoring Research Office, under Project VELA-UNIFORM, and accomplished under the technical direction of the Air Force Technical Applications Center under Contract Number F08606-76-C-0011.

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This fifth quarterly report summarizes progress under the VELA Network and Automatic Processing Research Program Contract Number F08606-76-C-0011, during the period 10 July 1976 to 10 October 1976. Work in the following areas is summarized:

- Array and network evaluation;
- Signal detection methods; signal estimation techniques; and discrimination.

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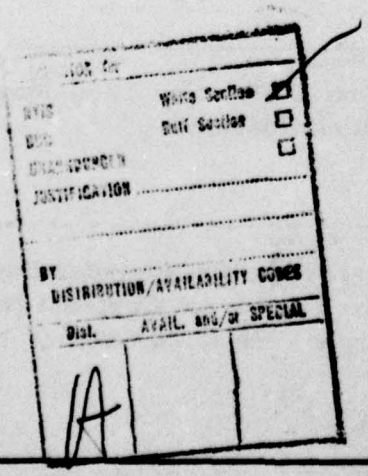
20. continued

- Signal estimation techniques
- Discrimination.



SUMMARY OF QUARTERLY RESEARCH

This fifth quarterly report summarizes the progress made during the period 10 July 1976 to 10 October 1976 in the VELA Network Evaluation and Automatic Processing Research program being carried out by Texas Instruments Incorporated at the Seismic Data Analysis Center (SDAC) in Alexandria, Virginia. Because much of the effort during this period was spent in the preparation of draft technical reports, and since the major conclusions from these reports will be presented in the final report, this quarterly report will have an abbreviated format. The four program tasks are:

- Array and network evaluation
- Signal detection methods
- Signal estimation techniques
- Discrimination.

A draft report presenting the preliminary evaluation of five Seismic Research Observatories (SRO's) has been written. The stations evaluated were: Albuquerque, New Mexico (ANMO); Guam, Marianas Island (GUMO); Mashhad, Iran (MAIO); Mundaring, Western Australia (NWAO); and Wellington, New Zealand (SNZO). Major areas of investigation covered by this report are data quality, RMS noise levels, spectral content of the noise, detection capability, and discrimination capability.

A similar draft report presenting a preliminary evaluation of the Iranian Long Period Array (ILPA) was also written. Major areas of investigation covered by this report are data quality and source of data errors, signal-to-noise ratio gains due to beamforming, detection capability, and seismic event M_s-m_b relationships.

During the last quarter all software development and checkout was completed for the task of developing software to transfer ILPA data from the SDAC via the ARPANET to the Mass Store. This work involved:

- Compilation and testing of final versions of ILPA Long-Period, Short-Period, and Coarse Status file and port specifications.
- Design, implementation, and testing of the complete ILPA Satellite Tape Re-format Program which generates Long-Period, Short-Period, and Coarse Status Files on 9 track, 1600 bpi tape that are compatible with corresponding ILPA port specifications.
- Specification of the Data Language entry procedure by which an operator may realistically transfer ILPA data files to the Mass Store.

To formally complete the ILPA Data Transfer Task, a demonstration will be conducted for the Air Force during which ILPA data will be transferred to and retrieved from Mass Store files managed by Computer Corporation of America's (CCA) 203 Datacomputer.

In the area of automatic signal detectors, a draft of the technical report was written. The major accomplishments during the last quarter can be summarized as follows:

- A least-squares estimate technique, which incorporates the detector's correct decision probability, was developed to fit the detector's percentages (in terms of m_b) to a Gaussian probability. This technique was applied to estimate the detection probability for the 181 events in January-February 1976 that were processed.
- Using three hour-long noise samples, false alarms were measured for the Fisher detector, the conventional (array beam) power detector, and the single sensor power detector.

- Beamforming loss measurements were taken for six events in the Kurile-Kamchatka region.

For the Adaptive Beamforming (ABF) detector, events from the Kurile-Kamchatka region were processed. The results were used to estimate the detection probability and obtain the Gaussian parameters. These results were included in a draft of the technical report which was completed during this past quarter. Attempts were also made to improve the adaptive filter algorithm. It was found that using an adaptive filter length equal to or less than the half period of the dominant noise energy in the low frequency pass-band improved the noise reduction.

During the past quarter, a pre-whitened matched filter was developed for the cascading study, and was shown to have a markedly better performance than a matched filter without pre-whitening. The Three-Component Adaptive Processor's (TCA) performance was also improved during this period by choosing filter weights by means of a Monte Carlo technique. A draft technical report on all the work to date was prepared.

For the dispersion filter task, methods for determining a signal's dispersion start time were investigated. The method of sliding the dispersion related filter through the input waveform yields the most accurate results, followed by maximum entropy spectrum analysis as the next most accurate. A rough draft of the technical report was completed.

For the PDP-15 discrimination task, we completed running the Short-Period Earthquake-Explosion Discriminator (SPEED) on a data base to determine the feasibility of using SPEED for a surveillance mode processing of events. Standard operating procedures were specified which could be automated. These involved straight Variable Frequency Magnitude (VFM) processing omitting cepstrum analysis, deconvolution, and absorption correction. The resultant data on spectral levels was analyzed by optimal multivariate discriminants to establish a baseline for short-period spectral discrimination.

The application of SPEED as a research tool for developing discrimination techniques has been demonstrated and documented. Any of the interactive techniques of SPEED should be implemented for routine discrimination processing only after adequate indications of its capability are shown over the baseline VFM capability which will be discussed in the forthcoming technical report. The main improvement needed in applying all of the SPEED capability to routine discrimination processing is in the cepstrum display, so that negative peaks can unambiguously be used to resolve echos. Relying simply on cepstrum displays is presently ambiguous due to the large negative peaks which are also observed for earthquakes. Our own and Lincoln Laboratory's research is currently directed toward prediction error filtering of cepstrum to provide a more definitive basis for identifying echos.

Finally, for the investigation of the use of higher modes for discrimination purposes, the ratio of the first higher mode (L_1) to fundamental mode (L_0) Love wave amplitude was examined and compared to model predictions for events from different structures in North America. The agreement was less than satisfactory but better than the agreement between theoretical and actual source models using the spectral fitting methods and first higher mode spectra only. A draft report on all of the work examining the use of first higher modes as a discriminant was prepared.